Data Science-Assignment-4-Project

April 28, 2020

Initially the dataset consisted of 13 columns, But Since Station Code and Agency wouldnn't have contributed to the visualization process, We removed them and made the dataset with 9 columns.

[1]:
```
#Importing the required libraries.
import seaborn as sns
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
```

[2]:
```
dataset = pd.read_csv('dataset.csv')
df = dataset.copy()
```

```
C:\ProgramData\Anaconda3\lib\site-
packages\IPython\core\interactiveshell.py:3051: DtypeWarning: Columns (0) have
mixed types. Specify dtype option on import or set low_memory=False.
  interactivity=interactivity, compiler=compiler, result=result)
```

[3]:
```
df.describe()
```

[3]:

	so2	no2	rspm	spm	pm2_5
count	401096.000000	419509.000000	395520.000000	198355.000000	9314.000000
mean	10.829414	25.809623	108.832784	220.783480	40.791467
std	11.177187	18.503086	74.872430	151.395457	30.832525
min	0.000000	0.000000	0.000000	0.000000	3.000000
25%	5.000000	14.000000	56.000000	111.000000	24.000000
50%	8.000000	22.000000	90.000000	187.000000	32.000000
75%	13.700000	32.200000	142.000000	296.000000	46.000000
max	909.000000	876.000000	6307.033333	3380.000000	504.000000

[4]:
```
df['type'].nunique()
```

[4]:
```
10
```

[5]:
```
df['type'].unique()
```

[5]:
```
array(['Residential, Rural and other Areas', 'Industrial Area', nan,
       'Sensitive Area', 'Industrial Areas', 'Residential and others',
       'Sensitive Areas', 'Industrial', 'Residential', 'RIRUO',
```

```
       'Sensitive'], dtype=object)
```

[6]:
```
df.info()
df.isnull().sum()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 435742 entries, 0 to 435741
Data columns (total 13 columns):
stn_code                        291665 non-null object
sampling_date                   435739 non-null object
state                           435742 non-null object
location                        435739 non-null object
agency                          286261 non-null object
type                            430349 non-null object
so2                             401096 non-null float64
no2                             419509 non-null float64
rspm                            395520 non-null float64
spm                             198355 non-null float64
location_monitoring_station     408251 non-null object
pm2_5                           9314 non-null float64
date                            435735 non-null object
dtypes: float64(5), object(8)
memory usage: 43.2+ MB
```

[6]:
```
stn_code                        144077
sampling_date                        3
state                                0
location                             3
agency                          149481
type                              5393
so2                              34646
no2                              16233
rspm                             40222
spm                             237387
location_monitoring_station      27491
pm2_5                           426428
date                                 7
dtype: int64
```

[7]:
```
print("Null values of column State ", df['state'].isnull().sum() )
print("Null values of column location ", df['location'].isnull().sum() )
print("Null values of column so2 ", df['so2'].isnull().sum() )
print("Null values of column no2 ", df['no2'].isnull().sum() )
print("Null values of column rspm ", df['rspm'].isnull().sum() )
print("Null values of column spm ", df['spm'].isnull().sum() )
print("Null values of column pm_2.5 ", df['pm2_5'].isnull().sum() )
print("Null values of column date ", df['date'].isnull().sum() )
```

```
Null values of column State  0
Null values of column location  3
Null values of column so2  34646
Null values of column no2  16233
Null values of column rspm  40222
Null values of column spm  237387
Null values of column pm_2.5  426428
Null values of column date  7
```

Reading

The following two lines are to get the information about the dataset i.e - The total number of attributes, their name, non-null as well as null numbered values, etc. The thing to note here is that the dataset is plagued with null entries which will make visualization of certain attributes unreasonable and useless.

[8]:
```
df.head(10)
```

[8]:

	stn_code	sampling_date	state	location	agency	type	so2	no2	rspm	spm	location_monitoring_station	pm2_5	date
0	150	February - M021990	Andhra Pradesh	Hyderabad	NaN	Residential, Rural and other Areas	4.8	17.4	NaN	NaN	NaN	NaN	2/1/1990
1	151	February - M021990	Andhra Pradesh	Hyderabad	NaN	Industrial Area	3.1	7.0	NaN	NaN	NaN	NaN	2/1/1990
2	152	February - M021990	Andhra Pradesh	Hyderabad	NaN	Residential, Rural and other Areas	6.2	28.5	NaN	NaN	NaN	NaN	2/1/1990
3	150	March - M031990	Andhra Pradesh	Hyderabad	NaN	Residential, Rural and other Areas	6.3	14.7	NaN	NaN	NaN	NaN	3/1/1990
4	151	March - M031990	Andhra Pradesh	Hyderabad	NaN	Industrial Area	4.7	7.5	NaN	NaN	NaN	NaN	3/1/1990
5	152	March - M031990	Andhra Pradesh	Hyderabad	NaN	Residential, Rural and other Areas	6.4	25.7	NaN	NaN	NaN	NaN	3/1/1990
6	150	April - M041990	Andhra Pradesh	Hyderabad	NaN	Residential, Rural and other Areas	5.4	17.1	NaN	NaN	NaN	NaN	
7	151	April - M041990	Andhra Pradesh	Hyderabad	NaN	Industrial Area	4.7	8.7	NaN	NaN	NaN	NaN	
8	152	April - M041990	Andhra Pradesh	Hyderabad	NaN	Residential, Rural and other Areas	4.2	23.0	NaN	NaN	NaN	NaN	
9	151	May - M051990	Andhra Pradesh	Hyderabad	NaN	Industrial Area	4.0	8.9	NaN	NaN	NaN	NaN	

```
6                          NaN     NaN  4/1/1990
7                          NaN     NaN  4/1/1990
8                          NaN     NaN  4/1/1990
9                          NaN     NaN  5/1/1990
```

<h1>The main attributes are-</h1>
1)SO2-So2 is the funndamental cause for acid rain.

2)NO2 - Similar to SO2 it has adverse effects. Main contributors are vehicles. 3)pm2.5 - They are called particulate matter. They have a diameter of less than 2.5 micrometer they are the most dangerous in all. Since very small, can't be seen and can cause various cardiovascular diseases depending on exposure. They are emmited by factories, industries,etc 4)rspm - They are called as residual particulate matter or also as pm10 i.e they have diameter of roughly less than 10 micrometer. they are less hazardous than pm2.5 but hazardous nonetheless. Emmited by factories,etc 5)type - It tells us about the area. i.e whether Industrial, Residential Rural, etc

[9]:
```
#Here, Uttarnchal is replaced by Uttarakhand because, officialy, Uttaranchal␣
↪was renamed as Uttarakhand.
replacements = {'state': {r'Uttaranchal': 'Uttarakhand', }}
df.replace(replacements, regex = True, inplace = True)
```

[10]:
```
df['agency'].value_counts()
```

[10]:
```
Maharashtra State Pollution Control Board                    27857
Uttar Pradesh State Pollution Control Board                  22686
Andhra Pradesh State Pollution Control Board                 19139
Himachal Pradesh State Environment Proection & Pollution Control Board    15287
Punjab State Pollution Control Board                         15232
                                                               …
Arunachal Pradesh State Pollution Control Board                 90
TNPC                                                            82
RPCB                                                            63
VRCE                                                            61
RJPB                                                            53
Name: agency, Length: 64, dtype: int64
```

[11]:
```
"""
It is apparent by looking at the types that we can categorize them in two main␣
↪types
Industrial and Residential
Others are redundant.
"""
df['type'].value_counts()
```

[11]:
```
Residential, Rural and other Areas    179014
Industrial Area                        96091
Residential and others                 86791
Industrial Areas                       51747
Sensitive Area                          8980
```

```
Sensitive Areas                          5536
RIRUO                                    1304
Sensitive                                 495
Industrial                                233
Residential                               158
Name: type, dtype: int64
```

[12]:
```
#deleting all values which have null in type attribute
df = df.dropna(axis = 0, subset = ['type'])
# deleting all values which are null in location attribute
df = df.dropna(axis = 0, subset = ['location'])
#deleting all null values in so2 attribute
df = df.dropna(axis = 0, subset = ['so2'])
```

Dealing with Null values

For the case of simplicity, the null values are just removed entirely. But, we can devise other methods to deal with null values such as replacing them with previous values, etc

[13]:
```
df.isnull().sum()
```

[13]:
```
stn_code                       119813
sampling_date                       0
state                               0
location                            0
agency                         125169
type                                0
so2                                 0
no2                              1981
rspm                            29643
spm                            228178
location_monitoring_station     20567
pm2_5                          386966
date                                4
dtype: int64
```

Just for the sake of visualization, we don't need the following attributes The Agency is the comapny which measures the measurements, this will not affect anything. The location monitoring system doesn't play any role in pollution. The Stn_code and sampling date are of no use either.

[14]:
```
del df['agency']
del df['location_monitoring_station']
del df['stn_code']
del df['sampling_date']
```

[15]:
```
df.head()
```

[15]:
```
            state   location                                type  so2   no2  \
0  Andhra Pradesh  Hyderabad  Residential, Rural and other Areas  4.8  17.4
1  Andhra Pradesh  Hyderabad                   Industrial Area  3.1   7.0
2  Andhra Pradesh  Hyderabad  Residential, Rural and other Areas  6.2  28.5
3  Andhra Pradesh  Hyderabad  Residential, Rural and other Areas  6.3  14.7
4  Andhra Pradesh  Hyderabad                   Industrial Area  4.7   7.5

   rspm  spm  pm2_5      date
0   NaN  NaN    NaN  2/1/1990
1   NaN  NaN    NaN  2/1/1990
2   NaN  NaN    NaN  2/1/1990
3   NaN  NaN    NaN  3/1/1990
4   NaN  NaN    NaN  3/1/1990
```

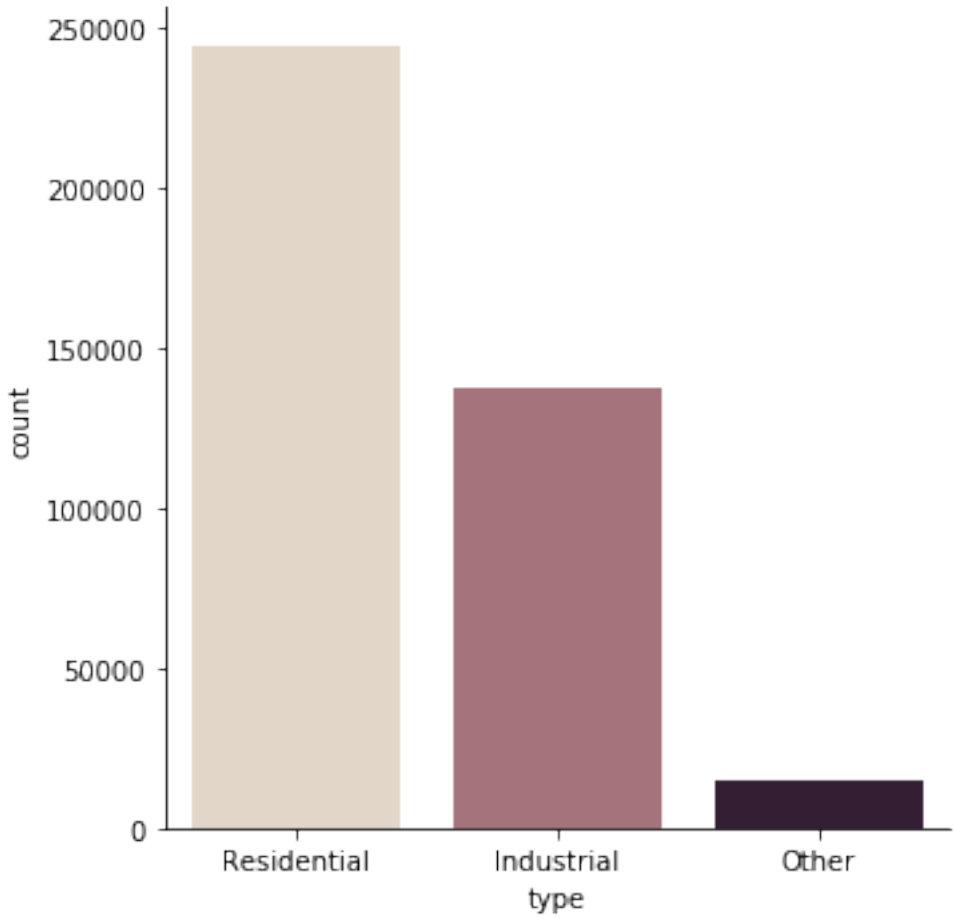
[16]:
```
a = list(df['type'])
for i in range(0, len(df)):
    if str(a[i][0]) == 'R' and a[i][1] == 'e':
        a[i] = 'Residential'
    elif str(a[i][0]) == 'I':
        a[i] = 'Industrial'
    else:
        a[i] = 'Other'

df['type'] = a
df['type'].value_counts()
```

[16]:
```
Residential    244017
Industrial     137420
Other           14724
Name: type, dtype: int64
```

As mentioned above, We can remove the redundant types and get only 2 main

[17]:
```
#how many observations belong to each location
sns.catplot(x = "type", kind = "count", palette = "ch: 0.25", data = df)
```

[17]:
```
<seaborn.axisgrid.FacetGrid at 0x1c91292d3c8>
```

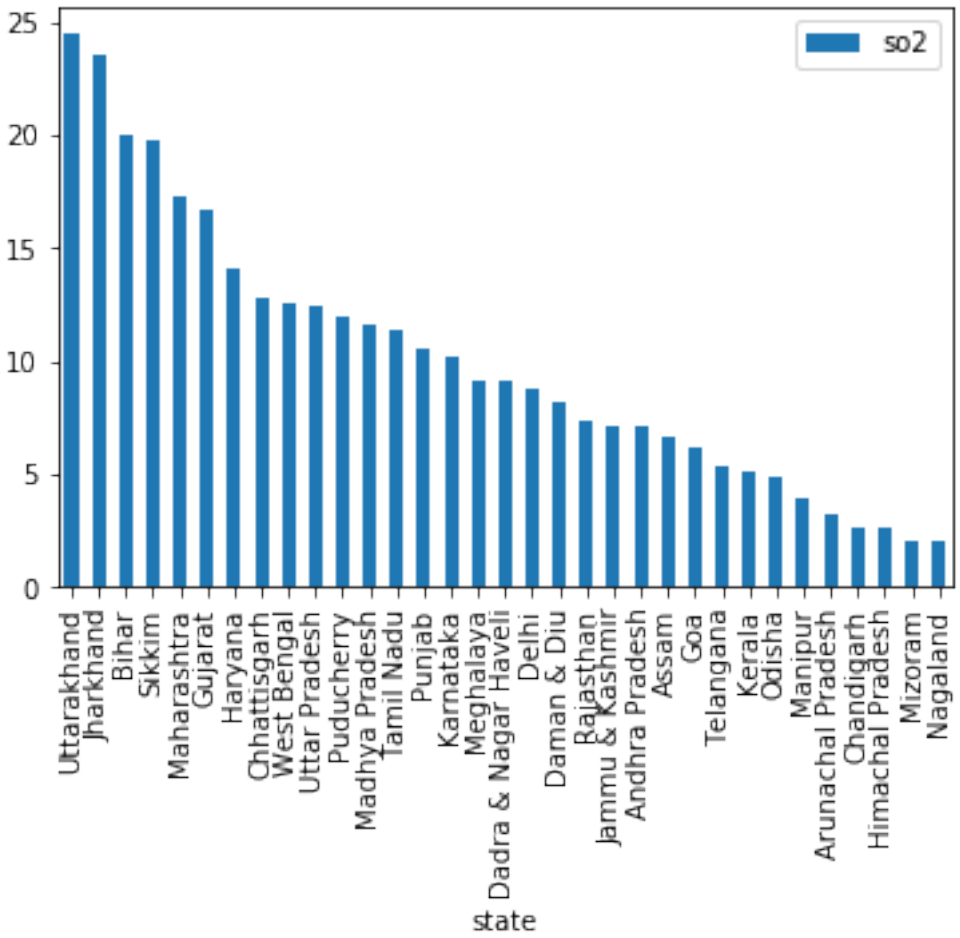


Main graphs

Following graphs are the mean values of attributes related with their particular states.

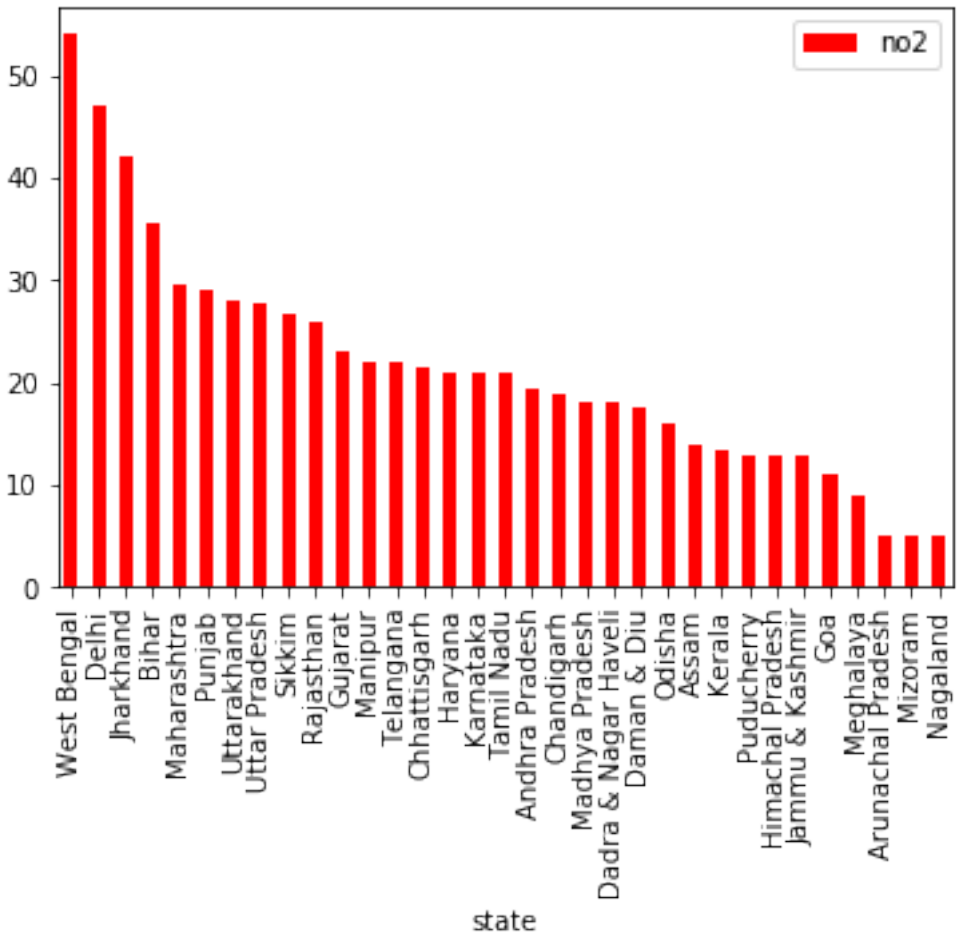
[18]:
```
#bar plot of so2 vs state - desc order
df[['so2', 'state']].groupby(['state']).mean().sort_values("so2", ascending =␣
↪False).plot.bar()
```

[18]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1c924f1b4e0>
```



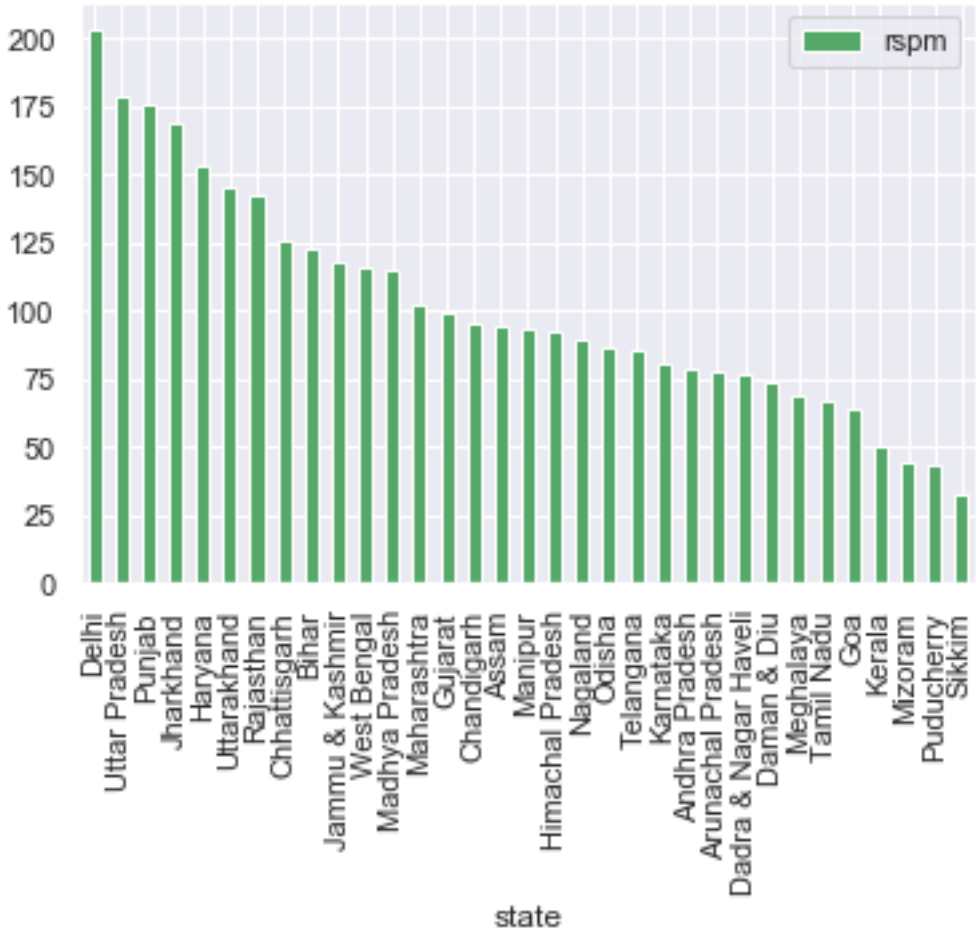
[19]:
```
# bar plot of no2 vs state - desc order
df[['no2', 'state']].groupby(['state']).median().sort_values("no2", ascending =␣
↪False).plot.bar(color = 'r')
```

[19]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91293fe10>



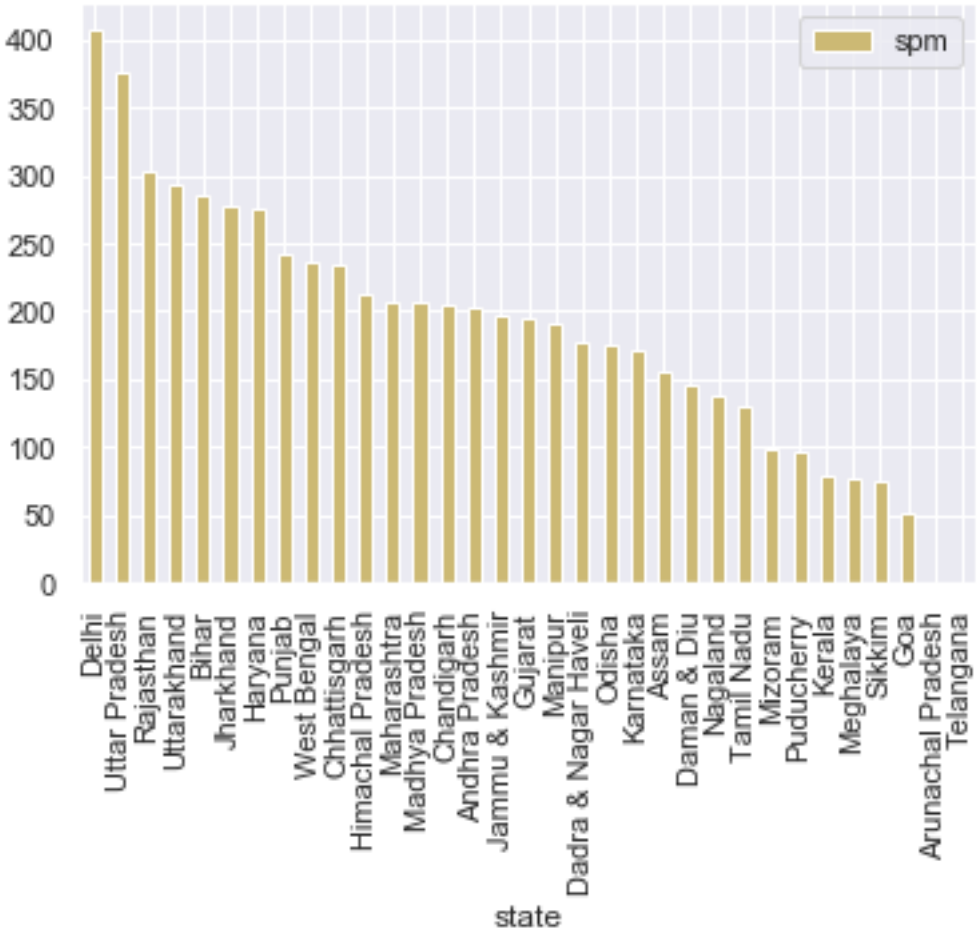
[125]:
```
# rspm = PM10
df[['rspm', 'state']].groupby(['state']).mean().sort_values("rspm", ascending =␣
↪False).plot.bar(color = 'g')
```

[125]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91a16ab00>



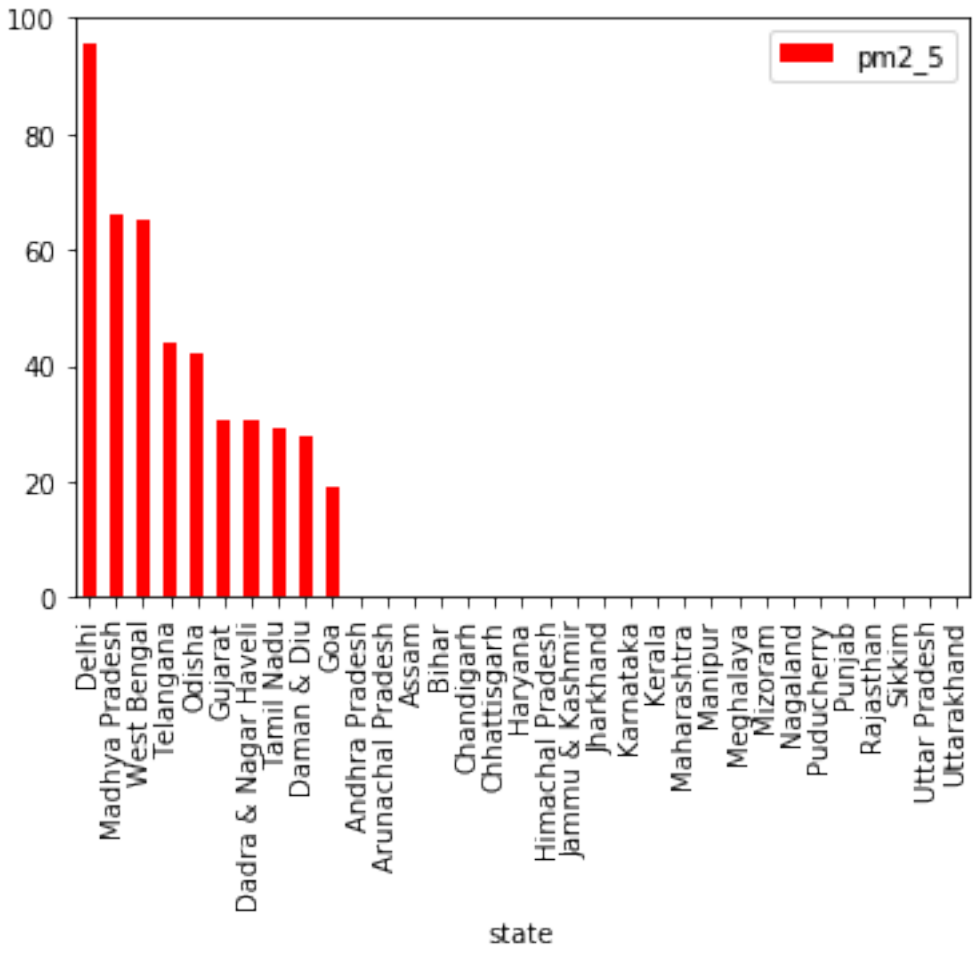
[127]:
```
# spm
df[['spm', 'state']].groupby(['state']).mean().sort_values("spm", ascending =␣
↪False).plot.bar(color = 'y')
```

[127]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91f5894a8>



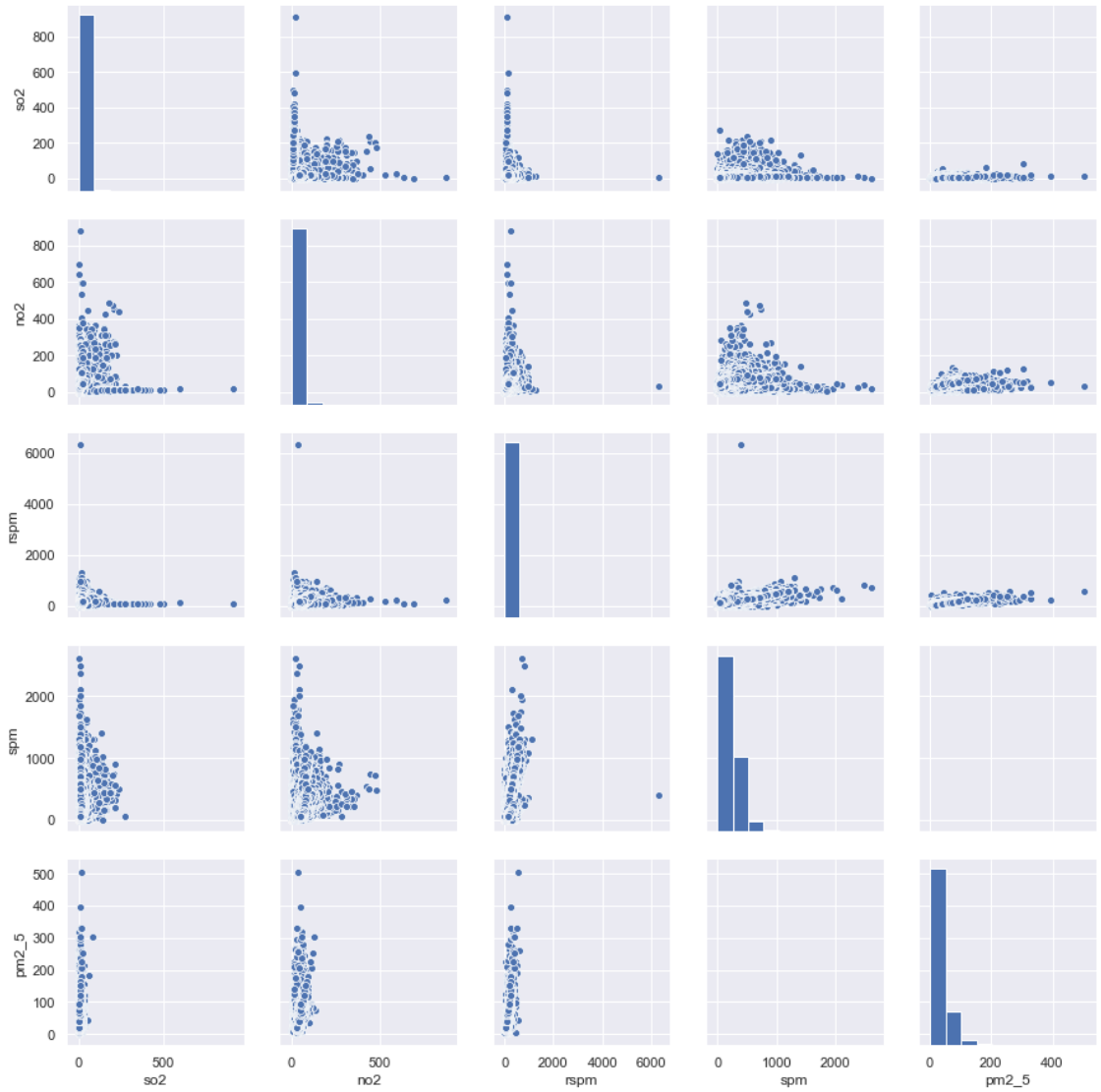
[22]:
```
# pm2_5
df[['pm2_5', 'state']].groupby(['state']).mean().sort_values("pm2_5", ascending␣
↪= False).plot.bar(color = 'r')
```

[22]: <matplotlib.axes._subplots.AxesSubplot at 0x1c9132ff898>



[23]:
```
#Scatter plots of all columns
sns.set()
cols = ['so2', 'no2', 'rspm', 'spm', 'pm2_5']
sns.pairplot(df[cols], size = 2.5)
plt.show()
```

```
C:\ProgramData\Anaconda3\lib\site-packages\seaborn\axisgrid.py:2065:
UserWarning: The `size` parameter has been renamed to `height`; pleaes update
your code.
  warnings.warn(msg, UserWarning)
C:\ProgramData\Anaconda3\lib\site-packages\numpy\lib\histograms.py:839:
RuntimeWarning: invalid value encountered in greater_equal
  keep = (tmp_a >= first_edge)
C:\ProgramData\Anaconda3\lib\site-packages\numpy\lib\histograms.py:840:
RuntimeWarning: invalid value encountered in less_equal
  keep &= (tmp_a <= last_edge)
```



Co-relation

The folloing graphs show relationship of each attribute with every other attribute via scatter plot. Scatter plot is choosen because it would give relationship between two attributes for corelation.

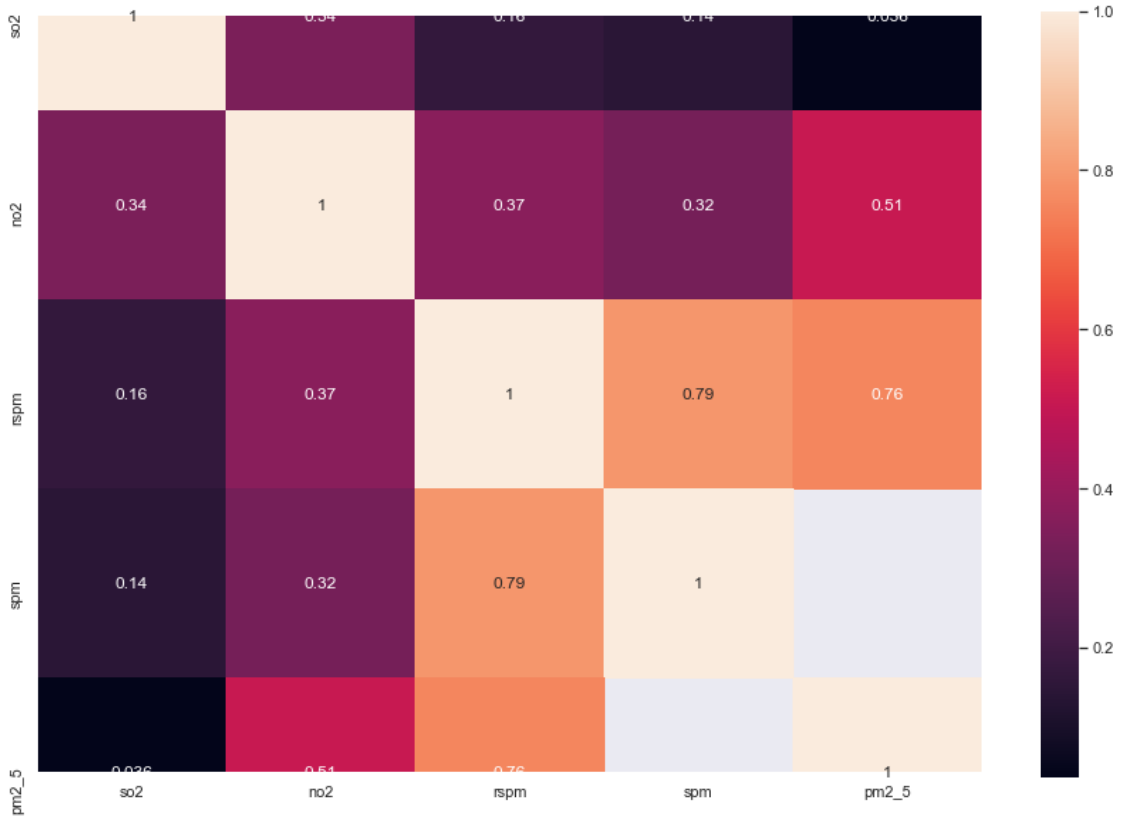
It should be expected that, as pm2.5 as ubiquitous null values, It shouln't be considered as to be delivering proper insights on corelation

From the following graphs, it can be deduced that so2 and no2 values are highly concentrated near to the origin, which means that both are low for most of the observations. We can see that no2 and so2 have a somewhat similar pattern with other features.

It can be said that spm and rspm share somewhat linear relationship, rest all features are not entirely related.

[24]:
```
corrmat = df.corr()
f, ax = plt.subplots(figsize = (15, 10))
sns.heatmap(corrmat, vmax = 1, annot = True, square = True)
```

[24]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1c91aac3128>
```



It can be deduced from the correlation matrix that spm and rspm have high corelation which was shown in the above graphs as well.

[25]:
```
df['state'].unique()
```

[25]:
```
array(['Andhra Pradesh', 'Arunachal Pradesh', 'Assam', 'Bihar',
       'Chandigarh', 'Chhattisgarh', 'Dadra & Nagar Haveli',
       'Daman & Diu', 'Delhi', 'Goa', 'Gujarat', 'Haryana',
       'Himachal Pradesh', 'Jammu & Kashmir', 'Jharkhand', 'Karnataka',
       'Kerala', 'Madhya Pradesh', 'Maharashtra', 'Manipur', 'Meghalaya',
       'Mizoram', 'Nagaland', 'Odisha', 'Puducherry', 'Punjab',
       'Rajasthan', 'Sikkim', 'Tamil Nadu', 'Telangana', 'Uttar Pradesh',
       'Uttarakhand', 'West Bengal'], dtype=object)
```

[26]:
```
"""
Creating a seperate dataframe for Andhra Pradesh having all the properties

"""
df_andhra = df.iloc[0:25086,:]
```

[27]:
```
len(df_andhra)
```

[27]:
```
25086
```

[28]:
```
df_andhra.head(10)
```

[28]:

	state	location	type	so2	no2	rspm	spm	pm2_5	date
0	Andhra Pradesh	Hyderabad	Residential	4.8	17.4	NaN	NaN	NaN	2/1/1990
1	Andhra Pradesh	Hyderabad	Industrial	3.1	7.0	NaN	NaN	NaN	2/1/1990
2	Andhra Pradesh	Hyderabad	Residential	6.2	28.5	NaN	NaN	NaN	2/1/1990
3	Andhra Pradesh	Hyderabad	Residential	6.3	14.7	NaN	NaN	NaN	3/1/1990
4	Andhra Pradesh	Hyderabad	Industrial	4.7	7.5	NaN	NaN	NaN	3/1/1990
5	Andhra Pradesh	Hyderabad	Residential	6.4	25.7	NaN	NaN	NaN	3/1/1990
6	Andhra Pradesh	Hyderabad	Residential	5.4	17.1	NaN	NaN	NaN	4/1/1990
7	Andhra Pradesh	Hyderabad	Industrial	4.7	8.7	NaN	NaN	NaN	4/1/1990
8	Andhra Pradesh	Hyderabad	Residential	4.2	23.0	NaN	NaN	NaN	4/1/1990
9	Andhra Pradesh	Hyderabad	Industrial	4.0	8.9	NaN	NaN	NaN	5/1/1990

[29]:
```
df_andhra.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 25086 entries, 0 to 26367
Data columns (total 9 columns):
state       25086 non-null object
location    25086 non-null object
type        25086 non-null object
so2         25086 non-null float64
no2         25063 non-null float64
rspm        24629 non-null float64
```

```
spm         11030 non-null float64
pm2_5       0 non-null float64
date        25086 non-null object
dtypes: float64(5), object(4)
memory usage: 1.9+ MB
```

[30]:
```
"""
Dropping pm2_5 as it has no non-null value
"""
df_andhra.drop('pm2_5', axis = 1, inplace = True)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\frame.py:4117:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  errors=errors,
```

[31]:
```
df_andhra.tail(10)
```

[31]:

	state	location	type	so2	no2	rspm	spm	date
26358	Andhra Pradesh	Rajahmundry	Industrial	7.0	21.0	72.0	NaN	11/25/2015
26359	Andhra Pradesh	Rajahmundry	Industrial	6.0	15.0	74.0	NaN	12/1/2015
26360	Andhra Pradesh	Rajahmundry	Industrial	7.0	17.0	62.0	NaN	12/4/2015
26361	Andhra Pradesh	Rajahmundry	Industrial	7.0	16.0	65.0	NaN	12/7/2015
26362	Andhra Pradesh	Rajahmundry	Industrial	8.0	18.0	70.0	NaN	12/10/2015
26363	Andhra Pradesh	Rajahmundry	Industrial	7.0	13.0	71.0	NaN	12/13/2015
26364	Andhra Pradesh	Rajahmundry	Industrial	7.0	18.0	77.0	NaN	12/16/2015
26365	Andhra Pradesh	Rajahmundry	Industrial	8.0	23.0	64.0	NaN	12/19/2015
26366	Andhra Pradesh	Rajahmundry	Industrial	7.0	19.0	61.0	NaN	12/22/2015
26367	Andhra Pradesh	Rajahmundry	Industrial	6.0	17.0	71.0	NaN	12/25/2015

[32]:
```
"""
Replacing the null values in rspm by the mean
```

```
"""
df_andhra['rspm'].fillna(df_andhra['rspm'].mean(), inplace = True)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\generic.py:6287:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self._update_inplace(new_data)
```

[33]:
```
"""
Replacing the null values in spm by the mean
"""
df_andhra['spm'].fillna(df_andhra['spm'].mean(), inplace = True)
```

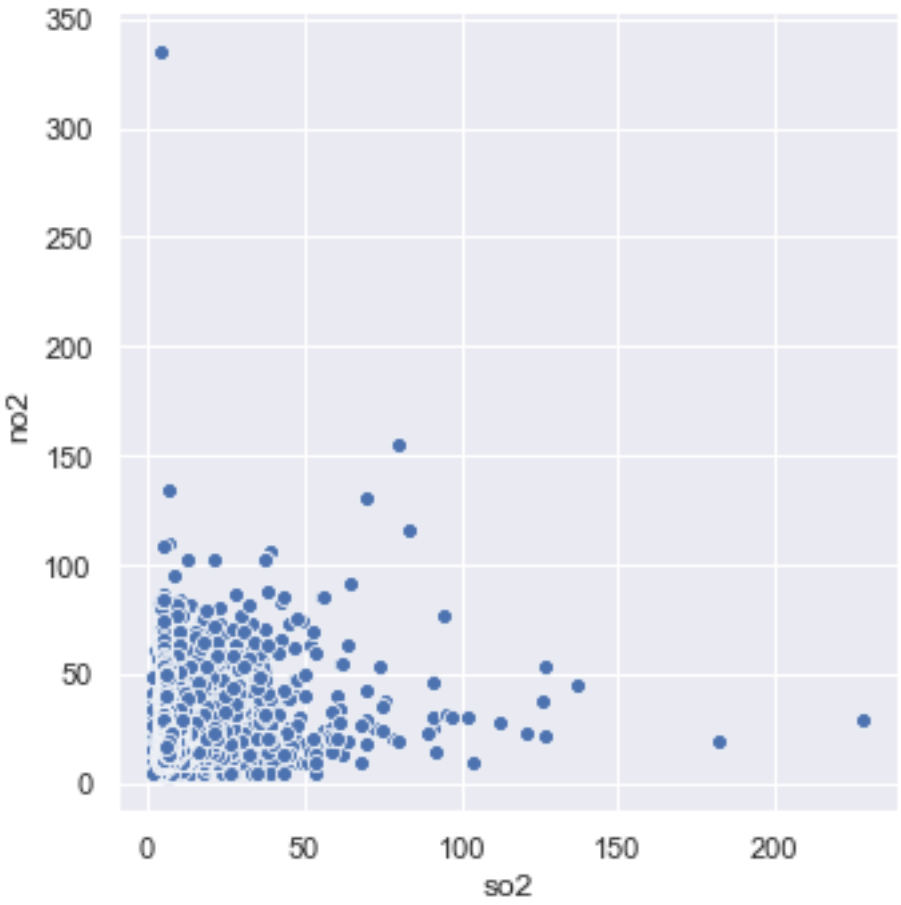
[34]:
```
df_andhra.head(10)
```

[34]:

	state	location	type	so2	no2	rspm	spm	\
0	Andhra Pradesh	Hyderabad	Residential	4.8	17.4	78.20071	202.379112	
1	Andhra Pradesh	Hyderabad	Industrial	3.1	7.0	78.20071	202.379112	
2	Andhra Pradesh	Hyderabad	Residential	6.2	28.5	78.20071	202.379112	
3	Andhra Pradesh	Hyderabad	Residential	6.3	14.7	78.20071	202.379112	
4	Andhra Pradesh	Hyderabad	Industrial	4.7	7.5	78.20071	202.379112	
5	Andhra Pradesh	Hyderabad	Residential	6.4	25.7	78.20071	202.379112	
6	Andhra Pradesh	Hyderabad	Residential	5.4	17.1	78.20071	202.379112	
7	Andhra Pradesh	Hyderabad	Industrial	4.7	8.7	78.20071	202.379112	
8	Andhra Pradesh	Hyderabad	Residential	4.2	23.0	78.20071	202.379112	
9	Andhra Pradesh	Hyderabad	Industrial	4.0	8.9	78.20071	202.379112	

	date
0	2/1/1990
1	2/1/1990
2	2/1/1990
3	3/1/1990
4	3/1/1990
5	3/1/1990
6	4/1/1990
7	4/1/1990
8	4/1/1990
9	5/1/1990

[35]:
```
sns.relplot(y="no2", x="so2",
            data=df_andhra);
```



[36]:
```
"""
Changing the format of the date column in df_andhra to datetime format
for the ease of calculation and further process
"""
df_andhra['date'] = pd.to_datetime(df_andhra['date'], format = "%m/%d/%Y")
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:5:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """
```

[37]:
```
df_andhra.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 25086 entries, 0 to 26367
```

```
Data columns (total 8 columns):
state       25086 non-null object
location    25086 non-null object
type        25086 non-null object
so2         25086 non-null float64
no2         25063 non-null float64
rspm        25086 non-null float64
spm         25086 non-null float64
date        25086 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(4), object(3)
memory usage: 1.7+ MB
```

[38]:
```
"""
Setting date as the index of df_andhra dataframe
"""
df_andhra.set_index('date', inplace = True)
```

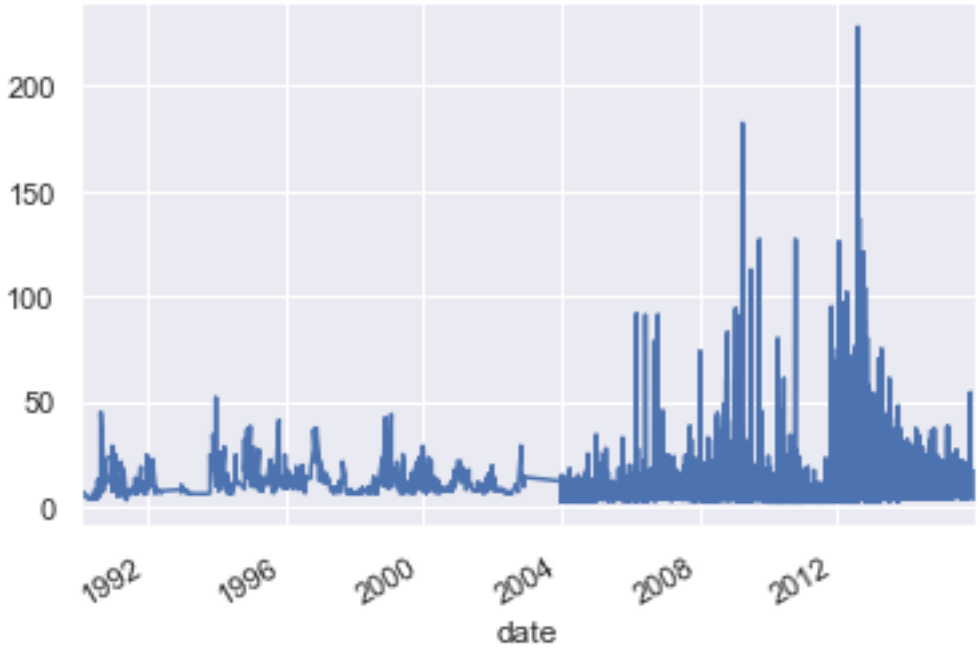
[39]:
```
df_andhra.head(10)
```

[39]:

date	state	location	type	so2	no2	rspm	spm
1990-02-01	Andhra Pradesh	Hyderabad	Residential	4.8	17.4	78.20071	202.379112
1990-02-01	Andhra Pradesh	Hyderabad	Industrial	3.1	7.0	78.20071	202.379112
1990-02-01	Andhra Pradesh	Hyderabad	Residential	6.2	28.5	78.20071	202.379112
1990-03-01	Andhra Pradesh	Hyderabad	Residential	6.3	14.7	78.20071	202.379112
1990-03-01	Andhra Pradesh	Hyderabad	Industrial	4.7	7.5	78.20071	202.379112
1990-03-01	Andhra Pradesh	Hyderabad	Residential	6.4	25.7	78.20071	202.379112
1990-04-01	Andhra Pradesh	Hyderabad	Residential	5.4	17.1	78.20071	202.379112
1990-04-01	Andhra Pradesh	Hyderabad	Industrial	4.7	8.7	78.20071	202.379112
1990-04-01	Andhra Pradesh	Hyderabad	Residential	4.2	23.0	78.20071	202.379112
1990-05-01	Andhra Pradesh	Hyderabad	Industrial	4.0	8.9	78.20071	202.379112

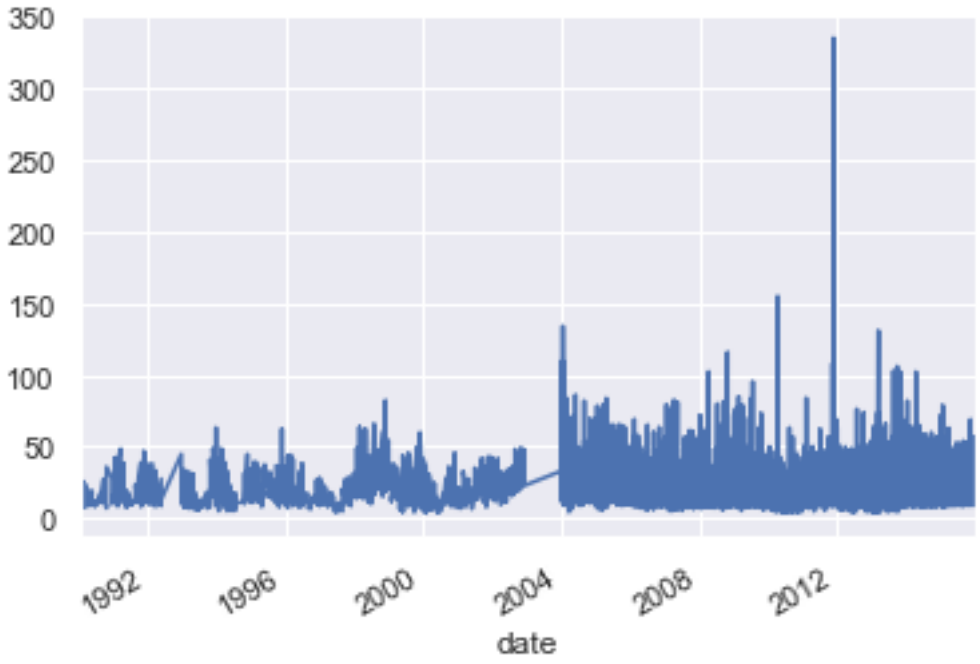
[40]:
```
df_andhra['so2'].plot(grid = True, kind = 'line')
```

[40]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91e9860b8>



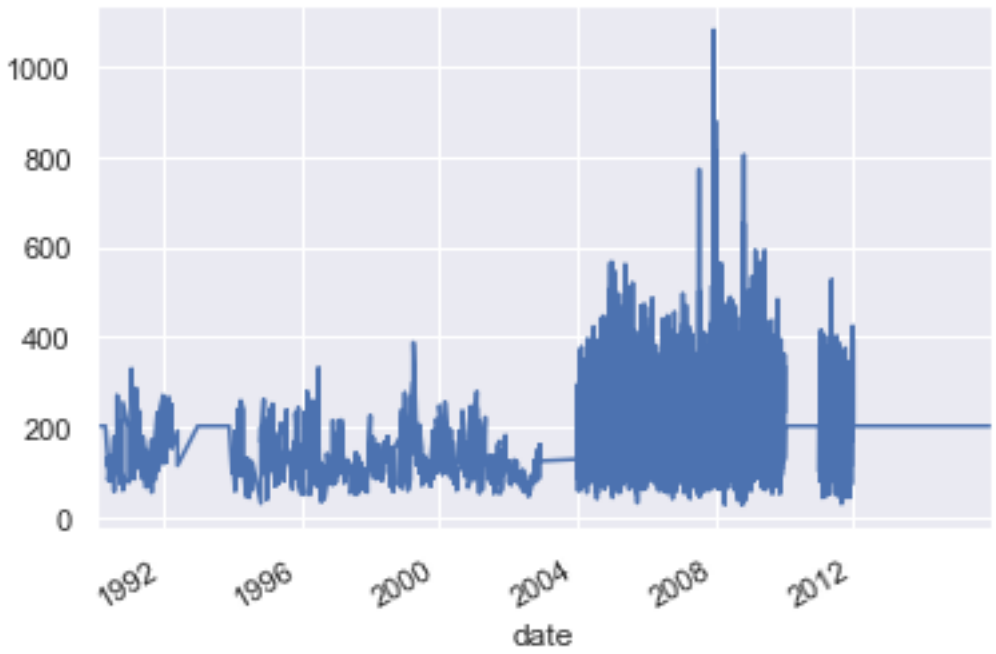
[41]:
```
df_andhra['no2'].plot(grid = True, kind = 'line')
```

[41]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91ead82e8>



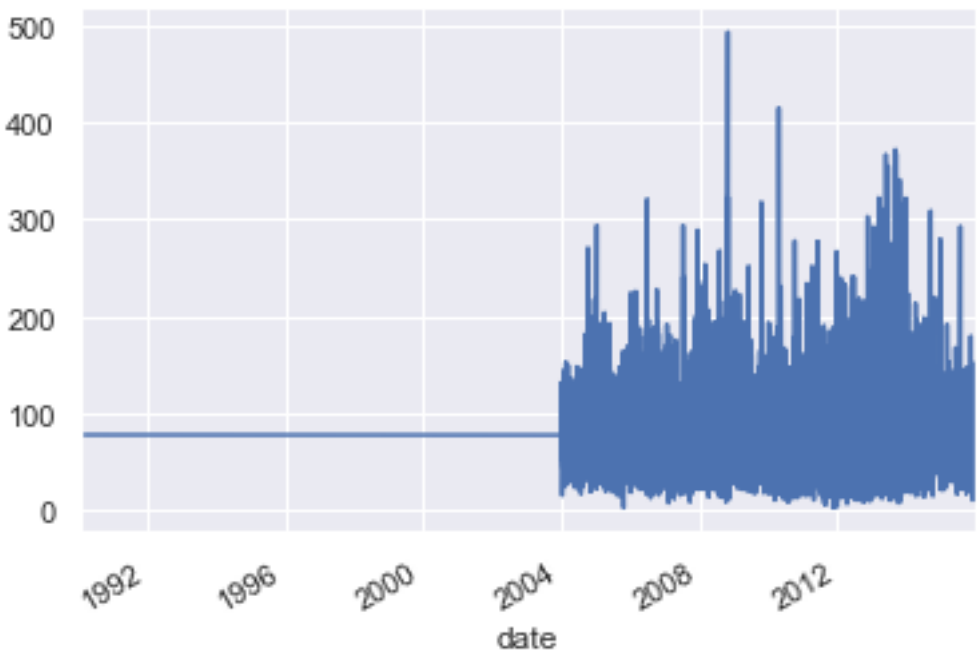
[42]:
```
df_andhra['spm'].plot(grid = True, kind = 'line')
```

[42]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91edf9780>



[43]:
```
df_andhra['rspm'].plot(grid = True, kind = 'line')
```

[43]: <matplotlib.axes._subplots.AxesSubplot at 0x1c91ef6e240>

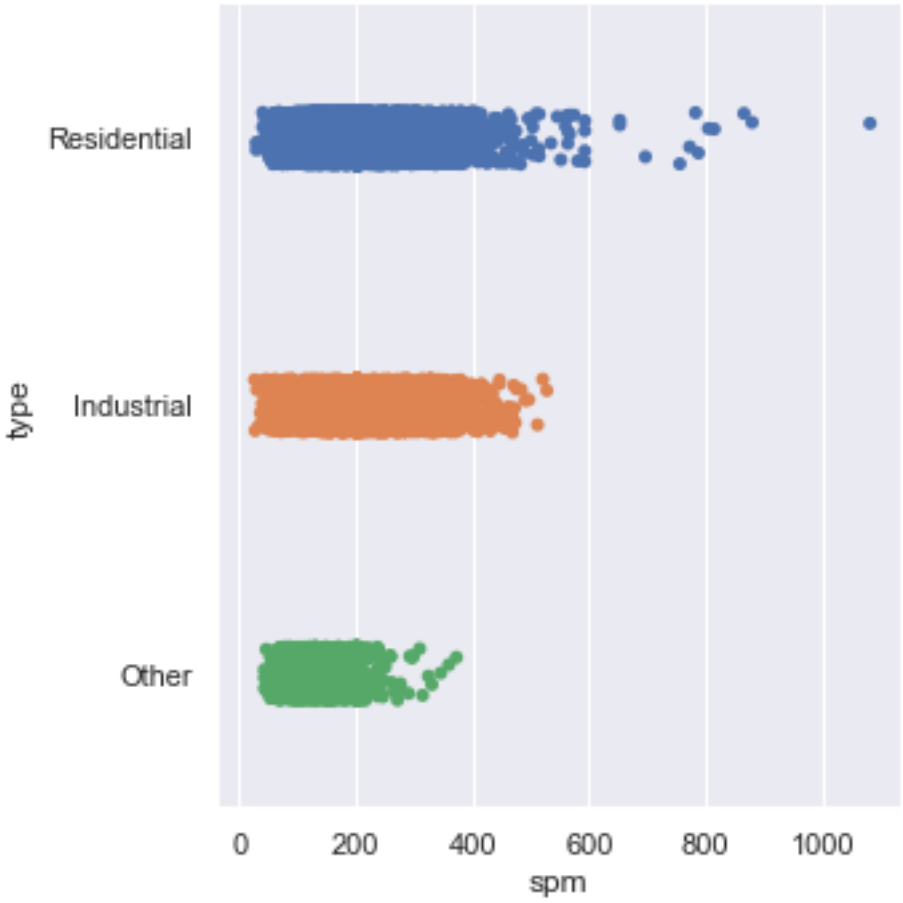


[44]:
```
df_andhra.head()
```

[44]:
```
                    state   location         type  so2   no2      rspm  \
date
1990-02-01  Andhra Pradesh  Hyderabad  Residential  4.8  17.4  78.20071
1990-02-01  Andhra Pradesh  Hyderabad   Industrial  3.1   7.0  78.20071
1990-02-01  Andhra Pradesh  Hyderabad  Residential  6.2  28.5  78.20071
1990-03-01  Andhra Pradesh  Hyderabad  Residential  6.3  14.7  78.20071
1990-03-01  Andhra Pradesh  Hyderabad   Industrial  4.7   7.5  78.20071

                  spm
date
1990-02-01  202.379112
1990-02-01  202.379112
1990-02-01  202.379112
1990-03-01  202.379112
1990-03-01  202.379112
```

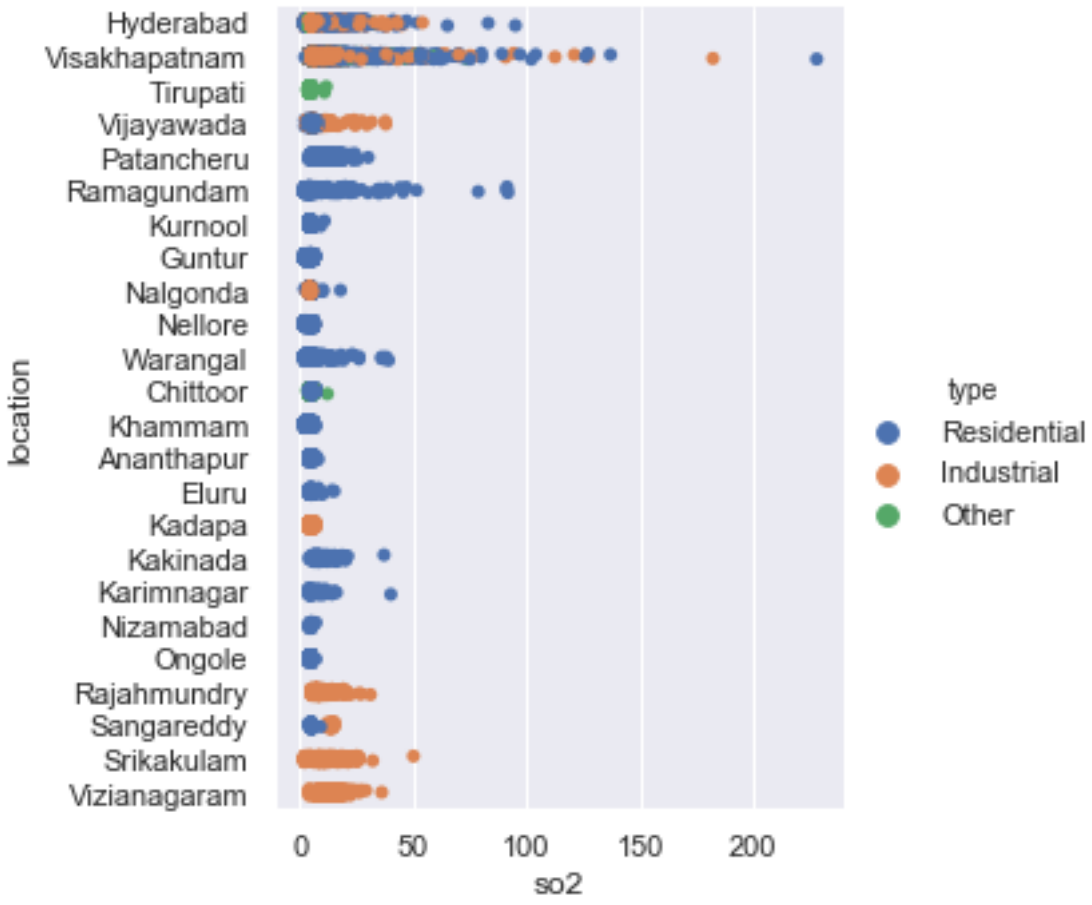
[45]:
```
sns.catplot(x = 'spm', y = 'type', data = df_andhra)
```

[45]:
```
<seaborn.axisgrid.FacetGrid at 0x1c91f20af28>
```



[46]:
```
sns.catplot(x = 'so2', y = 'location',hue = 'type' ,data = df_andhra)
```

[46]:
```
<seaborn.axisgrid.FacetGrid at 0x1c91f274208>
```



[47]:
```
df_andhra.drop('state',axis = 1, inplace = True)
```

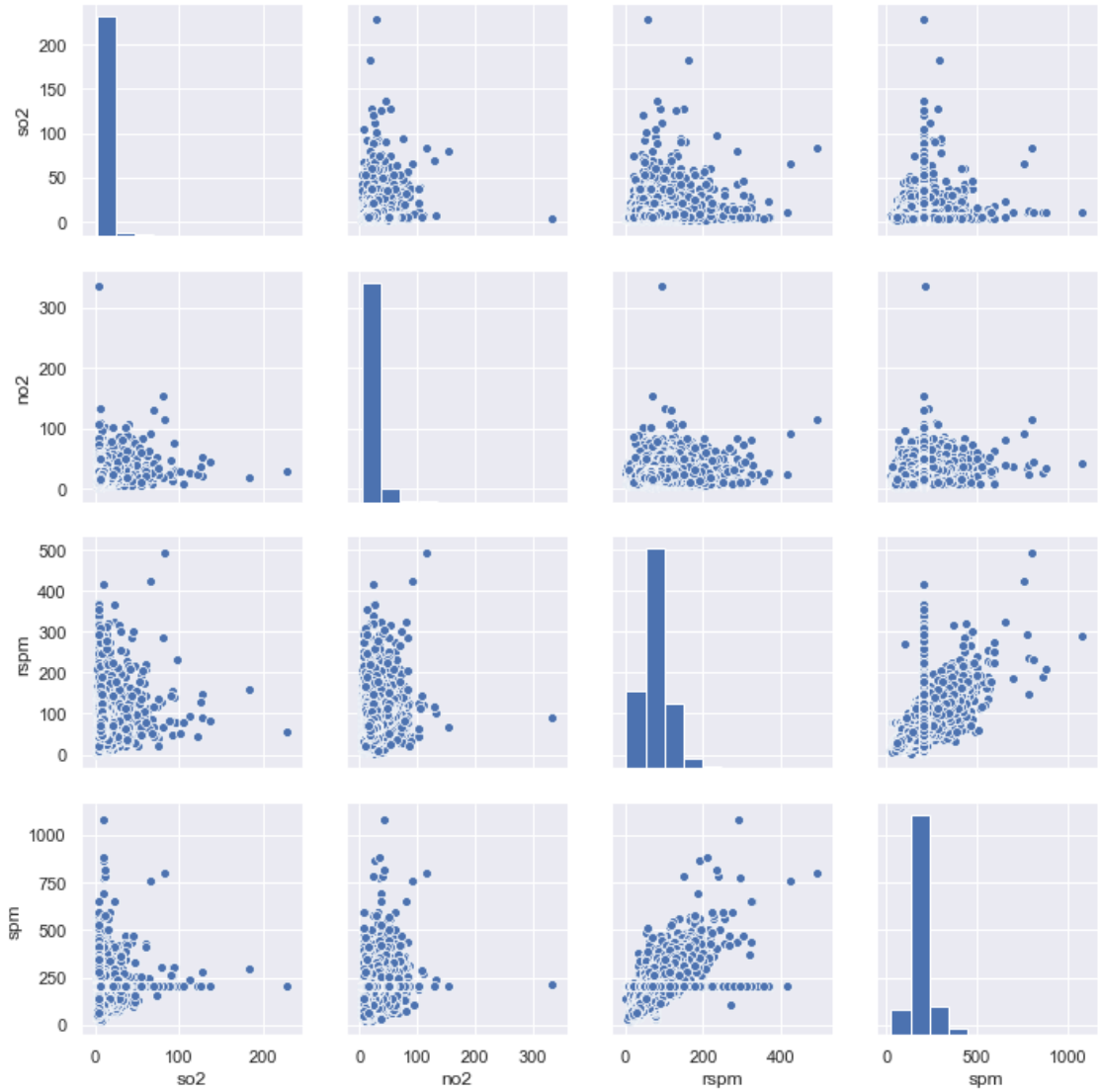
[48]:
```
df_andhra.head()
```

[48]:

date	location	type	so2	no2	rspm	spm
1990-02-01	Hyderabad	Residential	4.8	17.4	78.20071	202.379112
1990-02-01	Hyderabad	Industrial	3.1	7.0	78.20071	202.379112
1990-02-01	Hyderabad	Residential	6.2	28.5	78.20071	202.379112
1990-03-01	Hyderabad	Residential	6.3	14.7	78.20071	202.379112
1990-03-01	Hyderabad	Industrial	4.7	7.5	78.20071	202.379112

[49]:
```
sns.pairplot(df_andhra)
```

[49]:
```
<seaborn.axisgrid.PairGrid at 0x1c91f350cf8>
```



[50]:
```
"""
Encoding the data into numerical format as :
1 - ML models need data to be in numercial format
"""
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
for col in df_andhra:
    # Compare if the dtype is object
    if df_andhra[col].dtype=='object':
    # Use LabelEncoder to do the numeric transformation
        df_andhra[col]=le.fit_transform(df_andhra[col])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:11:
```

```
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  # This is added back by InteractiveShellApp.init_path()
```

[51]:
```
df_andhra
```

[51]:

date	location	type	so2	no2	rspm	spm
1990-02-01	4	2	4.8	17.4	78.20071	202.379112
1990-02-01	4	0	3.1	7.0	78.20071	202.379112
1990-02-01	4	2	6.2	28.5	78.20071	202.379112
1990-03-01	4	2	6.3	14.7	78.20071	202.379112
1990-03-01	4	0	4.7	7.5	78.20071	202.379112
…	…	…	…	…	…	…
2015-12-13	15	0	7.0	13.0	71.00000	202.379112
2015-12-16	15	0	7.0	18.0	77.00000	202.379112
2015-12-19	15	0	8.0	23.0	64.00000	202.379112
2015-12-22	15	0	7.0	19.0	61.00000	202.379112
2015-12-25	15	0	6.0	17.0	71.00000	202.379112

[25086 rows x 6 columns]

[52]:
```
"""
Creating seperate columns for encoded data
"""
from sklearn.preprocessing import OneHotEncoder
```

[53]:
```
enc = OneHotEncoder(handle_unknown='ignore')
```

[54]:
```
enc_df = pd.DataFrame(enc.fit_transform(df_andhra[['location']]).toarray())
```

[55]:
```
enc_df
```

[55]:

	0	1	2	3	4	5	6	7	8	9	…	14	15	16	\
0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	…	0.0	0.0	0.0	
1	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	…	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	…	0.0	0.0	0.0	
3	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	…	0.0	0.0	0.0	
4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	…	0.0	0.0	0.0	
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	
25081	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	…	0.0	1.0	0.0	
25082	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	…	0.0	1.0	0.0	
25083	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	…	0.0	1.0	0.0	

```
25084  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  …  0.0  1.0  0.0
25085  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  …  0.0  1.0  0.0

        17   18   19   20   21   22   23
0      0.0  0.0  0.0  0.0  0.0  0.0  0.0
1      0.0  0.0  0.0  0.0  0.0  0.0  0.0
2      0.0  0.0  0.0  0.0  0.0  0.0  0.0
3      0.0  0.0  0.0  0.0  0.0  0.0  0.0
4      0.0  0.0  0.0  0.0  0.0  0.0  0.0
…      …    …    …    …    …    …    …
25081  0.0  0.0  0.0  0.0  0.0  0.0  0.0
25082  0.0  0.0  0.0  0.0  0.0  0.0  0.0
25083  0.0  0.0  0.0  0.0  0.0  0.0  0.0
25084  0.0  0.0  0.0  0.0  0.0  0.0  0.0
25085  0.0  0.0  0.0  0.0  0.0  0.0  0.0

[25086 rows x 24 columns]
```

[56]:
```
df_andhra
```

[56]:
```
            location  type  so2   no2      rspm         spm
date
1990-02-01         4     2  4.8  17.4  78.20071  202.379112
1990-02-01         4     0  3.1   7.0  78.20071  202.379112
1990-02-01         4     2  6.2  28.5  78.20071  202.379112
1990-03-01         4     2  6.3  14.7  78.20071  202.379112
1990-03-01         4     0  4.7   7.5  78.20071  202.379112
…                …    …  …   …        …         …
2015-12-13        15     0  7.0  13.0  71.00000  202.379112
2015-12-16        15     0  7.0  18.0  77.00000  202.379112
2015-12-19        15     0  8.0  23.0  64.00000  202.379112
2015-12-22        15     0  7.0  19.0  61.00000  202.379112
2015-12-25        15     0  6.0  17.0  71.00000  202.379112

[25086 rows x 6 columns]
```

[57]:
```
x = df_andhra.index
enc_df['date'] = x
```

[58]:
```
enc_df.set_index('date', inplace = True)
```

[59]:
```
enc_df1 = pd.DataFrame(enc.fit_transform(df_andhra[['type']]).toarray())
```

[60]:
```
enc_df1
```

[60]:
```
          0    1    2
0       0.0  0.0  1.0
```

```
1       1.0  0.0  0.0
2       0.0  0.0  1.0
3       0.0  0.0  1.0
4       1.0  0.0  0.0
…     …  …  …
25081   1.0  0.0  0.0
25082   1.0  0.0  0.0
25083   1.0  0.0  0.0
25084   1.0  0.0  0.0
25085   1.0  0.0  0.0

[25086 rows x 3 columns]
```

[61]:
```
y = df_andhra.index
enc_df1['date'] = y
```

[62]:
```
enc_df1.set_index('date', inplace = True)
```

[63]:
```
enc_df1.rename(columns = {0 : 'a', 1 : 'b', 2: 'c'}, inplace = True)
```

[64]:
```
for i in range(0, 24):
    df_andhra[i] = enc_df[i]
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

[65]:
```
df_andhra
```

[65]:
```
            location  type  so2   no2      rspm         spm    0    1    2  \
date
1990-02-01         4     2  4.8  17.4  78.20071  202.379112  0.0  0.0  0.0
1990-02-01         4     0  3.1   7.0  78.20071  202.379112  0.0  0.0  0.0
1990-02-01         4     2  6.2  28.5  78.20071  202.379112  0.0  0.0  0.0
1990-03-01         4     2  6.3  14.7  78.20071  202.379112  0.0  0.0  0.0
1990-03-01         4     0  4.7   7.5  78.20071  202.379112  0.0  0.0  0.0
…                …    …  …   …        …          …   …   …   …
2015-12-13        15     0  7.0  13.0  71.00000  202.379112  0.0  0.0  0.0
2015-12-16        15     0  7.0  18.0  77.00000  202.379112  0.0  0.0  0.0
2015-12-19        15     0  8.0  23.0  64.00000  202.379112  0.0  0.0  0.0
2015-12-22        15     0  7.0  19.0  61.00000  202.379112  0.0  0.0  0.0
```

```
2015-12-25        15     0  6.0  17.0  71.00000  202.379112  0.0  0.0  0.0

              3  …   14   15   16   17   18   19   20   21   22   23
date             …
1990-02-01  0.0  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
1990-02-01  0.0  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
1990-02-01  0.0  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
1990-03-01  0.0  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
1990-03-01  0.0  …  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
…           …  …  …  …  …  …  …  …  …  …  …  …
2015-12-13  0.0  …  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
2015-12-16  0.0  …  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
2015-12-19  0.0  …  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
2015-12-22  0.0  …  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
2015-12-25  0.0  …  0.0  1.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

[25086 rows x 30 columns]
```

e

[66]:
```
df_andhra['a'] = enc_df1['a']
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """Entry point for launching an IPython kernel.
```

[67]:
```
df_andhra['b'] = enc_df1['b']
df_andhra['c'] = enc_df1['c']
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:1:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  """Entry point for launching an IPython kernel.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-
```

```
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
```

[68]:
```
df_andhra['no2'].isna().sum()
df_andhra['no2'].fillna(df_andhra['no2'].mean(), inplace = True)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\generic.py:6287:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  self._update_inplace(new_data)
```

[69]:
```
df_andhra.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 25086 entries, 1990-02-01 to 2015-12-25
Data columns (total 33 columns):
location    25086 non-null int32
type        25086 non-null int32
so2         25086 non-null float64
no2         25086 non-null float64
rspm        25086 non-null float64
spm         25086 non-null float64
0           25086 non-null float64
1           25086 non-null float64
2           25086 non-null float64
3           25086 non-null float64
4           25086 non-null float64
5           25086 non-null float64
6           25086 non-null float64
7           25086 non-null float64
8           25086 non-null float64
9           25086 non-null float64
10          25086 non-null float64
11          25086 non-null float64
12          25086 non-null float64
13          25086 non-null float64
14          25086 non-null float64
15          25086 non-null float64
16          25086 non-null float64
17          25086 non-null float64
18          25086 non-null float64
19          25086 non-null float64
20          25086 non-null float64
21          25086 non-null float64
22          25086 non-null float64
```

```
23          25086 non-null float64
a           25086 non-null float64
b           25086 non-null float64
c           25086 non-null float64
dtypes: float64(31), int32(2)
memory usage: 6.9 MB
```

[70]:
```
df_andhra['no2'].isna().sum()
```

[70]:
```
0
```

[71]:
```
y = df_andhra.iloc[:, 2:3].values
df_andhra.reset_index()
y.reshape(1,-1)
df_andhra.drop('so2', axis = 1, inplace = True)
df_andhra.drop('location', axis = 1, inplace = True)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\pandas\core\frame.py:4117:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  errors=errors,
```

[72]:
```
X = df_andhra.values
y.shape
```

[72]:
```
(25086, 1)
```

[124]:
```
X.shape
```

[124]:
```
(25086, 31)
```

[73]:
```
y
```

[73]:
```
array([[4.8],
       [3.1],
       [6.2],
       …,
       [8. ],
       [7. ],
       [6. ]])
```

[74]:
```
from sklearn.model_selection import train_test_split
```

[75]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2,␣
↪random_state = 23)
```

[76]:
```
X
```

[76]:
```
array([[ 2.        , 17.4       , 78.20070973, …,  0.        ,
         0.        ,  1.        ],
       [ 0.        ,  7.        , 78.20070973, …,  1.        ,
         0.        ,  0.        ],
       [ 2.        , 28.5       , 78.20070973, …,  0.        ,
         0.        ,  1.        ],
       …,
       [ 0.        , 23.        , 64.        , …,  1.        ,
         0.        ,  0.        ],
       [ 0.        , 19.        , 61.        , …,  1.        ,
         0.        ,  0.        ],
       [ 0.        , 17.        , 71.        , …,  1.        ,
         0.        ,  0.        ]])
```

[77]:
```
y
```

[77]:
```
array([[4.8],
       [3.1],
       [6.2],
       …,
       [8. ],
       [7. ],
       [6. ]])
```

[78]:
```
y.shape
```

[78]:
```
(25086, 1)
```

[79]:
```
np.isfinite(X.all())
```

[79]:
```
True
```

[80]:
```
np.any(np.isnan(X))
```

[80]:
```
False
```

[81]:
```
from sklearn.preprocessing import StandardScaler
sc_X = StandardScaler()
X_train = sc_X.fit_transform(X_train)
X_test = sc_X.transform(X_test)
```

[82]:
```
X_train
```

[82]:
```
array([[ 0.7654495 , -0.45403568,  0.13893762, …, -0.60006777,
        -0.39428202,  0.81529347],
```

```
       [ 0.7654495 ,  0.06788733, -1.68510909, …, -0.60006777,
        -0.39428202,  0.81529347],
       [-0.38726253, -1.13161993, -0.81651542, …, -0.60006777,
         2.53625562, -1.2265522 ],
       …,
       [ 0.7654495 , -1.31475081,  0.68904694, …, -0.60006777,
        -0.39428202,  0.81529347],
       [ 0.7654495 ,  1.1666726 ,  2.36832804, …, -0.60006777,
        -0.39428202,  0.81529347],
       [ 0.7654495 ,  0.44330563,  1.21020314, …, -0.60006777,
        -0.39428202,  0.81529347]])
```

[83]:
```
sc_y = StandardScaler()
y_train = sc_y.fit_transform(y_train)
```

[84]:
```
y_train
```

[84]:
```
array([[-0.39841891],
       [-0.49559107],
       [ 6.46841342],
       …,
       [-0.33363747],
       [ 2.92162974],
       [-0.2850514 ]])
```

[85]:
```
np.any(np.isnan(X))
```

[85]:
```
False
```

[114]:
```
from sklearn.ensemble import RandomForestRegressor
regressor = RandomForestRegressor(n_estimators = 1000, random_state = 0)
regressor.fit(X, y)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:3:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  This is separate from the ipykernel package so we can avoid doing imports
until
```

[114]:
```
RandomForestRegressor(bootstrap=True, ccp_alpha=0.0, criterion='mse',
                      max_depth=None, max_features='auto', max_leaf_nodes=None,
                      max_samples=None, min_impurity_decrease=0.0,
                      min_impurity_split=None, min_samples_leaf=1,
                      min_samples_split=2, min_weight_fraction_leaf=0.0,
                      n_estimators=1000, n_jobs=None, oob_score=False,
                      random_state=0, verbose=0, warm_start=False)
```

[115]:
```
y_pred = regressor.predict(X_test)
```

[116]:
```
predictor = regressor.predict(X_train)
```

[117]:
```
y_pred
len(y_pred)
len(y_train)
```

[117]: 20068

[118]:
```
print(len(y_pred))
print(len(y_test))
```

```
5018
5018
```

[119]:
```
from sklearn.metrics import r2_score
r2_score(y_test, y_pred)
```

[119]: -0.15743875150554376

[120]:
```
y_pred = sc_y.inverse_transform(y_pred)
```